Performance assessment of BlueINNOship maritime innovation network

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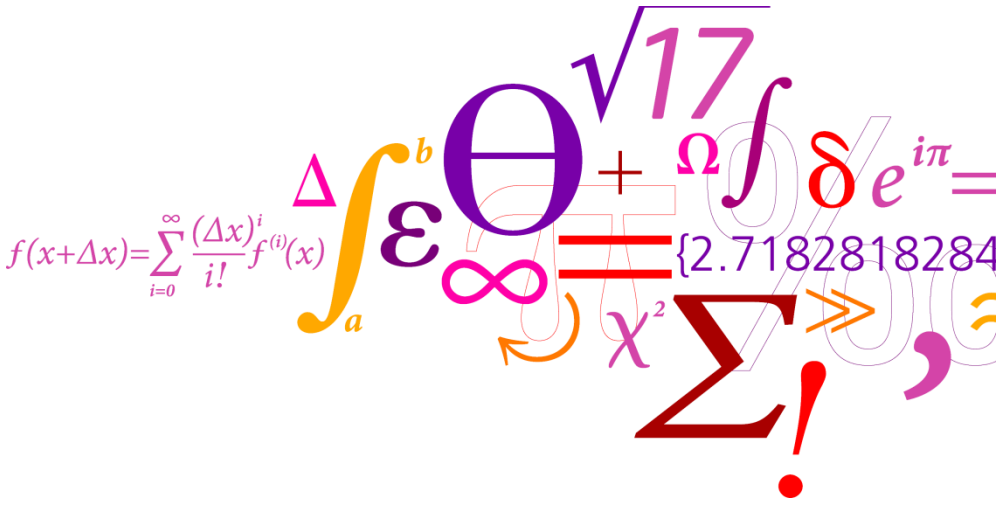

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Executive Summary

This report presents the findings of a study into the performance effects of BlueINNOship - a publicly funded innovation network in the Danish maritime industry. The study is based on a survey design of all BlueINNOship participants based on long-standing research on the innovation network. Based on the literature and the funding proposal of BlueINNOship, six performance factors were identified: dissemination, efficiency, networking capabilities, innovation capabilities, emission reduction, and growth.

The study results show that BlueINNOship exceeded many of the promises regarding dissemination. Furthermore, the network had a high positive effect on efficiency where the time requirements of innovation activities could be reduced through participation in the network. Furthermore, activities achieved budget constraints. BlueINNOship furthermore had a high effect on networking capabilities. Specifically, the network enabled the participating organisation to build closer relationships with existing partners such as customers, consultants and organisations. However, the building of relationships with new partners was not part of the performance effect of the network.

The study further shows that BlueINNOship created small effects in terms of innovation capabilities. This observation may be linked to the traditional innovation models applied in the Danish maritime sector. Finally, BlueINNOship created small effects for reduction of emission targets and growth. This contradicts an explicit aim of the network which was to reduce emissions from the maritime technology and to further growth in the Danish maritime sector.

The findings encourage changes to the Danish maritime sector which could further improve the positive effects of future innovation networks such as BlueINNOship. Based on this report, two changes in practice are proposed to ensure performance of future innovation networks in the Danish maritime sector. The first change in practice concerns more radical innovation approaches which include more risky projects including fundamentally new technologies. This could increase the effects on innovation capabilities and ultimately overall growth in the maritime sector. The second change in practice concerns to encouragement of the participation of new organisations in a future innovation network. This would enable the creation of new partnerships and new projects to further enhance the positive effect of a future innovation network. These proposed changes in practice could increase the performance effects of future innovation networks within the Danish maritime sector ensuring economic growth and competitiveness.

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This report presents the insights of the performance achievements of a publicly funded innovation network in the Danish maritime industry: BlueINNOship. The report is based on long-standing research on the innovation network and presents the findings of a performance assessment during the last half year of BlueINNOship.

Method

To assess the various outcomes of the BlueINNOship network, we studied what the participants achieved through their participation in the innovation network. A survey of all network participants (individuals and organisations) was conducted to get as broad an overview as possible and reduce bias regarding the answers. Additional qualitative insights were given by interviewees in the form of clarifications and evaluations via email and discussions.

For the performance assessment, the following topics were investigated:

- Innovation capabilities (new patents, new products/services/business models)
- Networking capabilities (closer relationships, new partners)
- Efficiency (shorter development cycles, cost savings)
- Growth (jobs, revenue, commercial contracts)
- Emission reduction
- Dissemination

These topics stemmed from the explicit goals expressed in the funding proposal for BlueINNOship, the motives of individual organisations to participate in BlueINNOship (obtained via an earlier study), and the wider literature on innovation networks (Cohen and Levinthal 1990, Spanos and Vonortas 2012, Buchmann and Pyka 2015). Twenty questions required direct answers either in the form of Yes/no or open entering of numbers of output. Eighteen questions were assessed via a 5-point likert scale ranging from “strongly disagree” to “strongly agree”. The appendix details the specific survey questions and answering choices.

Of the 66 individual participants of BlueINNOship (some individuals participated in more than one project), we received 55 complete responses. We analysed these responses quantitatively using descriptive statistics. The responses to the 5-point likert scale were numerated in the form that “strongly disagree” refers to a “1” and “strongly agree” to a “5” in line with standard procedure for quantitative analysis. Negative phrasings of specific questions were first translated into positive values to enable descriptive statistics. For the purpose of this report, the quantitative results were interpreted as follows:

- Values between 3 and 5 refer to a high effect of BlueINNO ship on the specific factor
- Values between 1 and 3 refer to a small effect of BlueINNO ship on the specific factor

Results

Figure 1 shows the overall results for the five performance topics which were obtained as the average values from all survey participants and all relevant questions for each topic (detailed in the Appendix). The results show that BlueINNOship improved efficiency and networking capabilities of

participating companies. The highest evaluation was given to efficiency with an average value of 3.85. Furthermore, the BlueINNOship created small effects in terms of innovation capabilities. This observation may be linked to the traditional innovation models applied in the Danish maritime sector. Finally, BlueINNOship created small effects for growth and reduction of emission targets. The sections below detail the specific outcomes of each of these topics as well as of the dissemination activities which were an explicit goal of BlueINNOship.

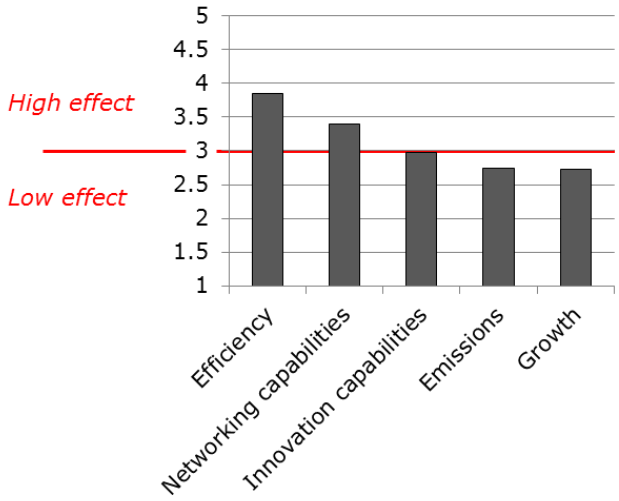

Figure 1: Mean values for five investigated performance topics

Dissemination

The funding proposal detailed specific goals for the outcome of this innovation network in terms of innovation and dissemination targets. Table 1 depicts the actual performance against the promised target values for these items. Table 1 shows that the actual outcome of BlueINNOship outperformed some of the target values – specifically with regard to new jobs, academic theses, and new academic courses. In other areas such as scientific journal articles and popular press articles, the actual outcome was lower than the promises. This may be attributed to long lead times in academic publications (review processes, multiple revision cycles etc) which may result in future increase in publications resulting from BlueINNOship. Thus, the final number of all publications resulting from the work carried out within the BlueINNOship innovation network may increase further beyond the numbers captured in this study.

Table 1: Comparison of target values and achieved performance

	New jobs	Scientific journal articles	Academic theses	New courses	Conference /workshop papers	Popular press articles
Target	0	35	24	3	4	21
Achieved	37	22	35	4	4	N/A

Efficiency

The performance regarding efficiency was found to be project dependent. Here, the survey participants were first asked to present the technological readiness of their project work based on the specific activities they have engaged in. These activities were given as follows:

1. Basic principles observed and reported: scientific research begins to be translated into applied research and development
2. Technology concept and/or application formulated: practical applications of those characteristics can be 'invented' or identified. At this level, the application is still speculative: there is not experimental proof or detailed analysis to support the conjecture.
3. Analytical and experimental critical function and/or characteristic proof of concept: active research and development (R&D) is initiated including both analytical studies to set the technology into an appropriate context and laboratory-based studies to physically validate that the analytical predictions are correct. These studies and experiments should constitute "proof-of-concept" validation of the applications/concepts formulated at TRL 2.
4. Component and/or breadboard validation in laboratory environment: Following successful "proof-of-concept" work, basic technological elements must be integrated to establish that the "pieces" will work together to achieve concept-enabling levels of performance for a component and/or breadboard. This validation must be devised to support the concept that was formulated earlier, and should also be consistent with the requirements of potential system applications. The validation is "low-fidelity" compared to the eventual system: it could be composed of ad hoc discrete components in a laboratory.
5. Component and/or breadboard validation in relevant environment: the fidelity of the component and/or breadboard being tested is increased significantly. The basic technological elements are integrated with reasonably realistic supporting elements so that the total applications (component-level, sub-system level, or system-level) can be tested in a 'simulated' or somewhat realistic environment.
6. System/subsystem model or prototype demonstration in a relevant environment: a representative model or prototype system or system - which goes well beyond ad hoc, 'patch-cord' or discrete component level breadboarding - is tested in a relevant environment. For example, the model/prototype is demonstrated at sea.
7. System prototype demonstration in operational environment: requires an actual system prototype demonstration in a maritime environment. The prototype is near or at the scale of the planned operational system and the demonstration must take place at sea.
8. Actual system completed and qualified through test and demonstration: In almost all cases, this level is the end of true 'system development' for most technology elements. This might include integration of new technology into an existing system.
9. Actual system proven in operational environment: In almost all cases, the end of last 'bug fixing' aspects of true 'system development'. This might include integration of new technology into an existing system. Not included are planned product improvements of ongoing or reusable systems.

Figure 4 depicts the results of the survey responses showing the differences between the projects with regard to technological readiness of the developed product.

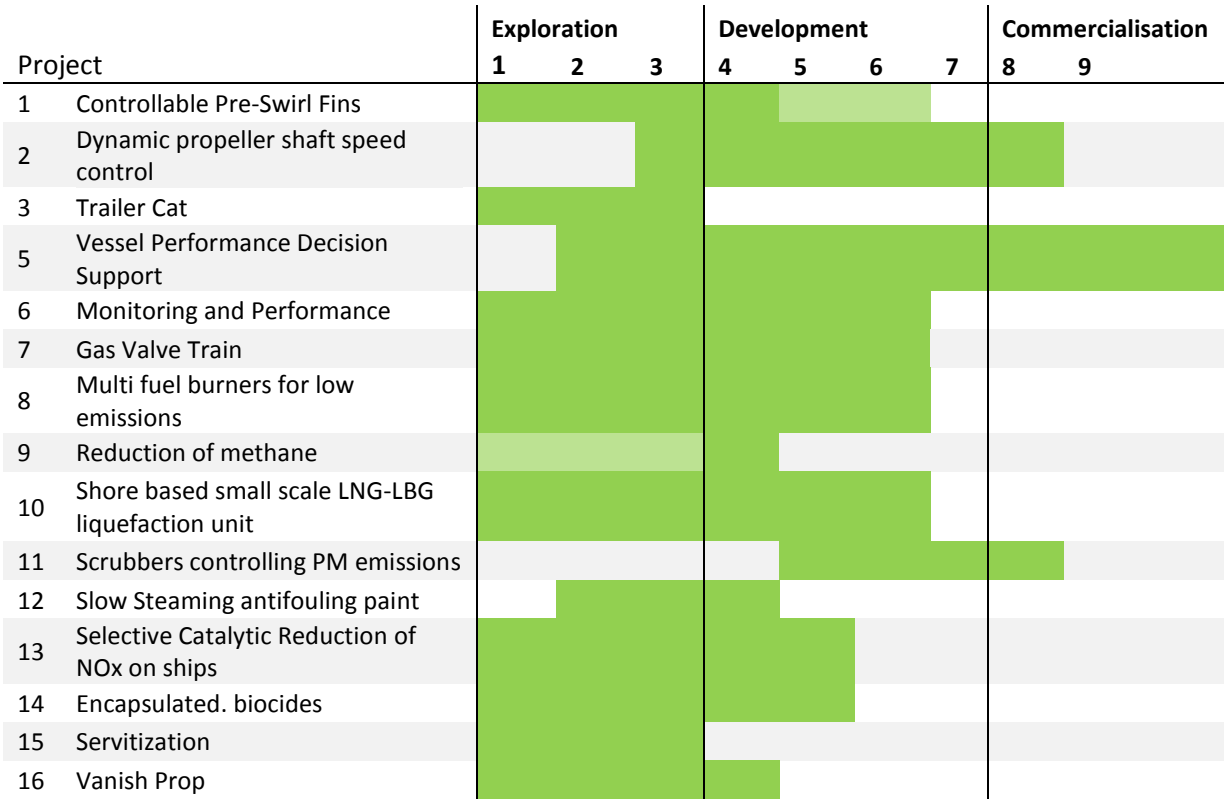

Figure 2: Technological readiness levels of the individual projects within BlueINNOship

We further assessed efficiency with respect to reducing timescales for innovation activities and meeting budget expectations. Table 2 depicts the mean values of efficiency effects from participation in the BlueINNOship network with regard to these two factors. In general, BlueINNOship created a small effect in terms of time savings for innovation activities. Only Projects 8, 10, 13, 14 and 16 experienced a large time-saving effect through their participation in the network. In contrast, all project experienced a high and positive budgeting effect through participating in BlueINNOship. This observation may arise from the availability of external funds with the creation of the innovation network adding to potential internal funds of the participating organisations. BlueINNOship thus created important synergy effects with strong contribution to the efficiency of innovation in the sector.

Table 2: Efficiency effects of participating in BlueINNOship depending on project

Project	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16
	Controllable Pre-Swirl Fins	Dynamic propeller shaft speed control	Trailer Cat	Vessel Performance Decision Support	Monitoring and Performance	Gas Valve Train	Multi fuel burners for low emissions	Reduction of methane	Shore based small scale LNG-LBG liquefaction unit	Scrubbers controlling PM emissions	Slow Steaming antifouling paint	Selective Catalytic Reduction of NOx on ships	Encapsulated. biocides	Servitization	Vanish Prop
Time reduction	2.6	3.5	3.6	3.5	3.0	3.0	4.0	3.0	4.0	3.5	1.5	3.8	4.5	3.3	4.5
Within budget	4.0	4.5	4.3	4.7	4.0	3.8	4.3	4.5	3.7	4.5	4.5	4.3	4.0	4.0	5.0

Networking capabilities

BlueINNOship created a high effect on networking capabilities in general. This finding is not surprising given the secondary purpose of innovation networks in fostering inter-organisational collaboration (Turpin et al. 1996). BlueINNOship thus followed suit in this approach offering a useful basis for the participating organisations to network and collaborate.

The assessment of networking capabilities focused on (a) increasing closeness with existing partners, (b) creating new relationships, (c) furthering new projects with existing partners, (d) enabling projects with new partners, and (e) the overall difference to the network of the participating organisation. Figure 3 summarises the performance results from the survey with respect to networking capabilities. Our results showed a strong effect for (a) increasing closeness of existing relationships through the specific collaboration within BlueINNOship. A particularly strong effect was observed here for Equipment Manufacturers (EMs), Consultancies, Designers and Classification society (Class). This finding can be linked to the conservative nature of the Danish maritime industry with regard to partnering and collaboration where existing partners are prioritised over new networks.

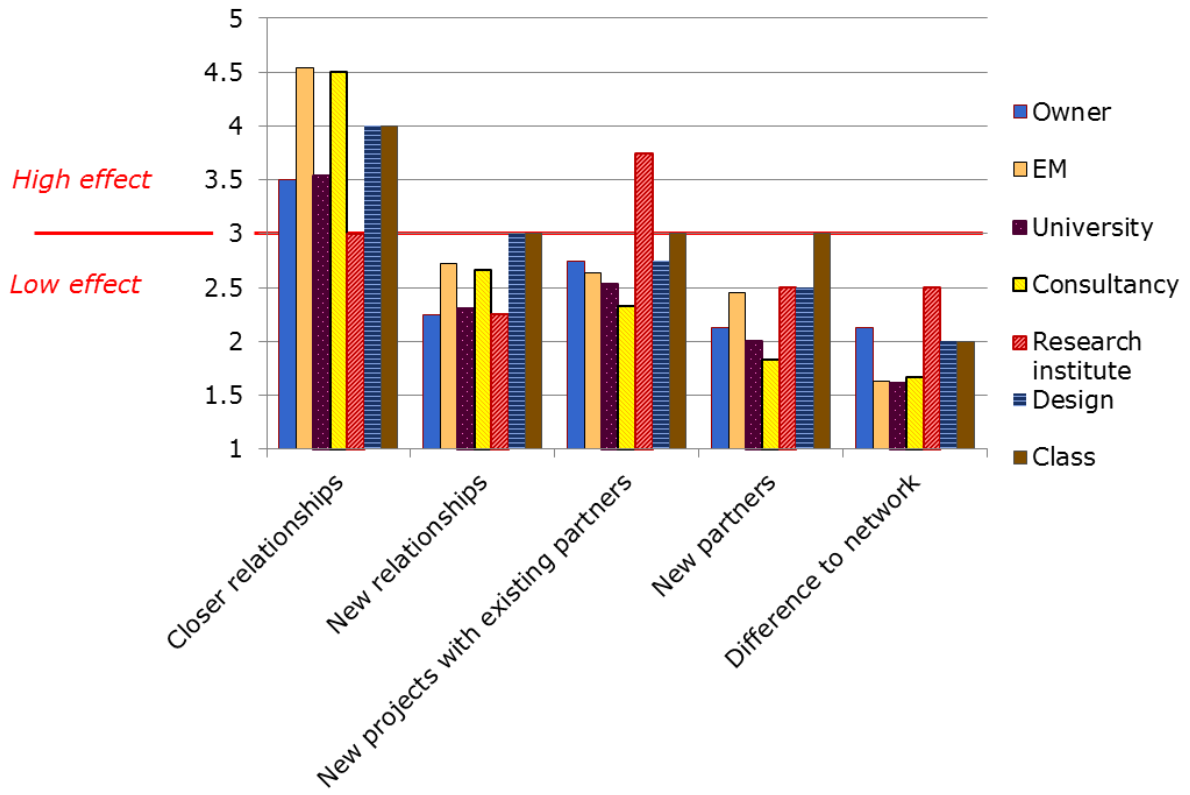

Figure 3: Networking capabilities through participation in BlueINNOship

On the remaining factors of networking capabilities, the findings indicate small effects of the participation in BlueINNOship. Specifically, the innovation network made a small difference to the network of participating organisations as a whole. This can again be attributed to the conservative nature of the Danish maritime industry with regard to partnering where existing partners are prioritised. Thus, the effects of BlueINNOship on networking capabilities are a direct result of the overall partnering approach in the Danish maritime industry.

Innovation capabilities

Innovation capabilities were positively affected by the participation in BlueINNOship. The overall effect was assessed as relatively low which may be attributed to the traditional innovation models predominantly applied in the maritime sector (Perunovic et al. 2016). Despite this low effect, participation in BlueINNOship received a positive assessment by the participants in terms of its effect on innovation capabilities. This is an encouraging finding for network management and future policy. It shows the usefulness of organising innovation in an innovation network and suggests potential for further improvements based on more radical innovation models.

We assessed the innovation capabilities through (a) the number of patents (submitted and planned) and (b) the generation of new ideas, products, services or other business models. Six new patents emerged from the participation in BlueINNOship based on our survey responses. These were all

submitted patent applications at the time of investigation and were based on responses from two Equipment manufacturers (EMs).

Figure 2 depicts the average values for the likert-scale based questions regarding innovation capabilities as a break-down depending on organisation type. The analysis of organisation type was based on the organisation self-characterisation (in their marketing material etc) and contribution to BlueINNOship. Figure 2 shows substantial differences between the different organisation types participating in the network. Consultancies experienced the highest effects in innovation capabilities with an overall average of 3.84. This high effect arose from new ideas, new products, and new business models in particular. Similarly, Equipment manufacturers (EMs) benefited strongly from the participation in BlueINNOship with regard to their innovation capabilities, specifically focusing on new ideas (and patents as described above). These were the two largest groups of organisations participating in the innovation network (17 of the 36 organisations in total, 10 EMs and 7 consultancies).

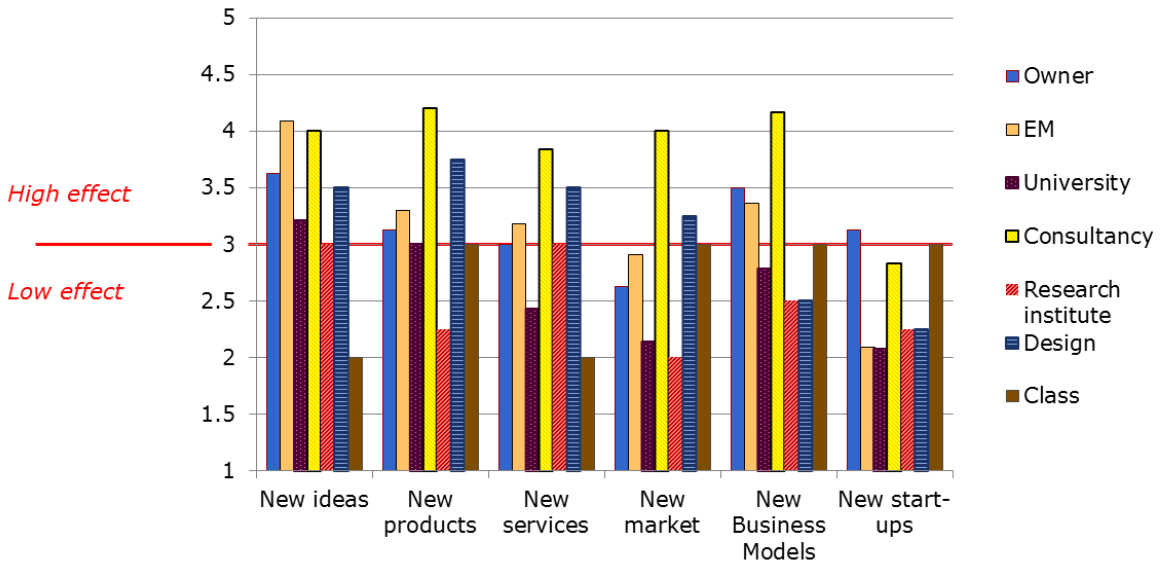

Figure 4: Innovation capabilities from BlueINNOship by question

In contrast, organisations such as universities, research institutes and classification societies (class) experienced smaller effects on their innovation capabilities. This finding may be attributed to the nature of these organisations as universities and research institutes tend to externalise developed innovation capabilities in spin-outs and other entrepreneurial activities. This can explain the relatively small effect of BlueINNOship on innovation capabilities in these organisation types.

Emission reduction

BlueINNOship created a small effect on reducing emission targets. Emission reduction was assessed with regard to reduced emissions of Sulfur oxides (SOx), nitrogen oxides (NOx) and Carbon dioxide

(CO2). Figure 6 sows the results of the evaluations of the survey participants showing no significant reduction in the emissions based on the work in BlueINNOship. This contradicts explicit aims of the innovation network which stated emission reduction as a performance outcome of BlueINNOship.

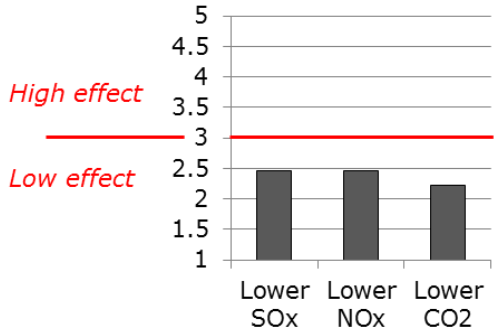

Figure 5: Results regarding emission reduction

Growth

BlueINNOship created a small effect on growth in general. This finding can be linked to the effect on networking capabilities as organisations were found to prioritise increasing the closeness of existing partnerships over building new relationships and over creating new projects. This suggests that the innovation network functioned as a vehicle for furthering existing business pathways rather than opening up new opportunities in the form of new relationships and new projects which would have resulted in higher growth effects.

Growth was assessed via the additional jobs created through the innovation network, increased revenues, and additional commercial contracts signed through the work in BlueINNOship. The survey showed that in total 37 additional jobs were created through BlueINNOship (total additional jobs at the time of the survey and planned jobs in the future). This exceeded the expected number of jobs substantially as presented in Table 1. This finding may be explained with the direct investment in this innovation network via external funds which enabled hiring of new staff including doctoral students and other staff.

Increased revenues and additional contracts were assessed using a five point likert scale. Figure 5 shows the survey results regarding these two factors of assessing growth. BlueINNOship showed small effects for both these factors indicating a low effect of participating in the innovation network on increasing revenues and enabling new business contracts. These findings can be linked to the findings of innovation capabilities and networking capabilities presented above. The Danish maritime sector currently favours traditional models of innovation and networking where more conservative product development projects with existing partners are encouraged. This means that new business opportunities focus on existing markets including customers and supply chains. This strategy thus limits the overall potential for increasing revenues and additional contracts and explains the findings of this survey regarding BlueINNOship.

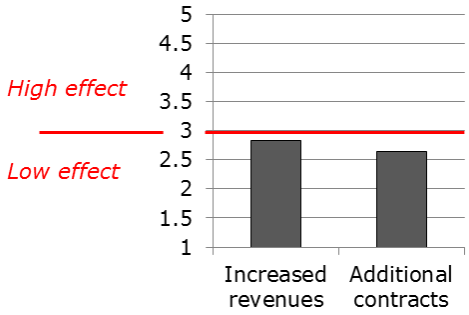

Figure 6: Growth effects through BlueINNOship

Conclusions

Summary

Based on a survey of participants of BlueINNOship, the study focused on analysing the performance effects on dissemination, efficiency, networking capabilities, innovation capabilities, emission reduction and growth, revealing two important insights. First, the participation in the innovation network had strong effects with respect to improving the efficiency of innovations and with respect to networking capabilities. The reason for these observations can be seen in the effects on creating closer relationships with existing partners. Second, BlueINNOship had small but positive effects on innovation capabilities, growth and emission reduction. This finding arose from the conservative nature of the specific innovation projects within the network favouring small-scale developments of product parts and new technologies.

Furthermore, BlueINNOship can be expected to have future indirect performance effect arising from some of the specific measurable performance indicators. For example, the network performed above expectations with regard to dissemination activities such as journal and conference publications, academic theses and university courses. These measurable performance indicators create the relevant surroundings within the maritime sector to foster future innovativeness and thus form an indirect performance effect. It can thus be concluded that the innovation network was a useful tool for creating the industrial context for future innovations in terms of communications and personnel competencies.

Study limitations

The presented results were obtained as the innovation network was still ongoing and thus present an evaluation of the short-term performance. The literature suggests that participation in innovation networks can result also in long-term performance improvements such as sparking and enabling future innovation activities (Bozeman and Youtie 2017). This long-term performance was, however, excluded from this research and was not the focus of our work. We thus refrain from applying the presented conclusions to potential long-term effects of the participation in BlueINNOship.

Furthermore, this survey was undertaken with network participants only. The literature suggests that innovation networks can have wider performance effects by changing whole technological

ecosystems or industrial sectors (Toole 2012, Buchmann and Pyka 2015). However, this survey and thus the presented results were based on the network participants' evaluation of the performance through their participation and thus excluded potential wider effects.

Finally, the presented results are based on a survey within a single innovation network. It can thus be seen as a single case. The presented results are not generalizable to other publicly funded innovation networks, other industry sectors, other approaches to administering and managing the innovation network.

Final remarks

The findings encourage changes to the Danish maritime sector which could further improve the positive effects of future innovation networks such as BlueINNOship. Specifically, two changes arise from the findings presented in this report. First, more radical innovation approaches which include more risky projects including fundamentally new technologies could increase the effects on innovation capabilities and ultimately overall growth in the maritime sector. Specifically new products or services that expand the business model portfolio of the participating organisations in terms of breadth (fundamentally new types of products or services) and depth (increasing the absolute sales of existing products and services) would increase the growth effect of a future innovation network in the Danish maritime sector substantially.

Second, encouraging the participation of new organisations in a future innovation network that enables the creation of new partnerships and new projects would further enhance the positive effect of a future innovation network. Such a more open approach would widen the enable the creation of new markets and new supply structures which could create new business opportunities and thus increase the long-term effects of participating in an innovation network. Through these two changes, future innovation networks could create even stronger positive effects than created through BlueINNOship.

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Appendix

Survey questionnaire

Area	Question	Answer options
Innovation capabilities	Q1: Our organization's participation in the BlueInno Ship network has resulted in new patent applications.	Yes, No, Do not know
	Q1a: If yes, How many patent applications have you submitted?	Open
	Q2: We are planning patent applications at the moment based on our participation in the BlueInno Ship network.	Yes, No, Do not know
	Q2a: How many patent applications are you planning at the moment?	Open
	Q3: Our organisation's participation in the BlueInno Ship network has resulted in new ideas regarding future products and technologies.	5-point likert scale
	Q4: We have developed new product(s) based on our participation in the BlueInno Ship network.	5-point likert scale
	Q5: We have developed new service(s) (e.g. consulting, teaching, maintenance) based on our participation in the BlueInno Ship network.	5-point likert scale
	Q6: We are currently planning to market (commercially sell or offer) our developed product or service from BlueInno.	5-point likert scale
	Q7: We do currently **not** have a defined business model for our developed product or service from BlueInno Ship.	5-point likert scale
	Q8: The work in the BlueInno Ship network has enabled the creation of new start-up firms.	5-point likert scale
Efficiency	Q9: My organisation participated in the following project(s) in BlueInno Ship (please tick as many as relevant)	Multiple choice of 14 projects
	Q10: In [Project x] the project team covered the following activities (tick all activities that are relevant):	Multiple choice of 9 technology readiness levels
	Q11: Our participation in BlueInno has reduced the time of developing new technology in comparison to developing this technology outside of the network.	5-point likert scale
	Q12: We expect to be able to reach our project goals within budget.	5-point likert scale
Networking capabilities	Q13: Our organisation's participation in the BlueInno Ship network has enabled us to build closer relationships with existing partners (i.e. partners we had worked with before our participation).	5-point likert scale
	Q14: Our organisation's participation in the BlueInno Ship network has enabled us to build relationships with new partners (i.e. partners we never worked with before our participation).	5-point likert scale
	Q15: Through our participation in BlueInno, we have started new projects with partners we had worked with before.	5-point likert scale
	Q16: Through our participation in BlueInno, my company has **not** been able to work with new partners (i.e. partners we had not worked with before).	5-point likert scale
	Q17: Our participation in the BlueInno network has made **no** difference to our network of partners.	5-point likert scale

Growth	Q18: Our participation in BlueInno has resulted in additional jobs within our organisation.	Yes/No
	Q18a: If yes, How many jobs have been created so far through the participation in BlueInno?	Open
	Q19: We expect to hire new people within the near future based on the activities within the BlueInno network.	Yes/No
	Q19a: If yes, How many additional people are you expecting to hire based on the activities within BlueInno?	Open
	Q20: We expect to increase our revenues based on the activities within the BlueInno network.	5-point likert scale
	Q21: We have **not** been able to sign any additional commercial contracts based on our participation in BlueInno.	5-point likert scale
Emission reduction	Q22: Through our participation in BlueInno, we now offer technology that lowers SOx emission in comparison to before participating in the network.	5-point likert scale
	Q23: We have **not** been able to develop technology that reduces NOx emissions in comparison to before participating in the network through participating in BlueInno.	5-point likert scale
	Q24: Through our participation in BlueInno, we now offer technology that lowers CO2 emissions in comparison to before participating in the network.	5-point likert scale
Dissemination	Q25: Based on our participation in BlueInno, we have published scientific journal papers.	Yes/No
	Q25a: If yes, How many journal papers have you published based on your work in BlueInno?	Open
	Q26: Based on our participation in BlueInno, we have participated in academic theses (Bachelor theses, Master theses, PhD theses or similar).	Yes/No
	Q26a: If yes, How many theses have you been invovled in?	Open
	Q27: Based on our participation in BlueInno, we have developed/participated in developing new courses (academic courses on Bachelor/Master or PhD level, industrial courses).	Yes/No
	Q27a: If yes, How many new courses have you created?	Open
	Q28: Based on our participation in BlueInno, we have presented our work at industry events and conferences.	Yes/No
	Q28a: If yes, How many industry evens ant conferences have you attended based on your work in BlueInno?	Open
	Q29: Based on our participation in BlueInno, we have published articles in the industry and popular press (Politiken, Ingeniøren etc).	Yes/No
	Q29a: How many articles in the industry and popular press have you published based on your work in BlueInno?	Open

Key to answer choices:

5-point likert scale: from “strongly disagree” to “strongly agree”

Multiple choice of 9 technology readiness levels: see description on p.5 of this report